Web-Based Pipeline Integrity Assessment System Using Image Processing and AI Classification of Rust Severity

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Abstract

Dexon Technology Public Company Limited requires a web-based application to receive images from users and display pipeline defect analysis results. This project, “Web-Based Pipeline Integrity Assessment System Using Image Processing and AI Classification of Rust Severity”, was conducted under a cooperative education program. The developed system addresses issues of fragmented data and enhances the convenience of monitoring results by allowing users to upload inspection images, view prediction outcomes, and access summarized information through a single page. The workflow involves (1) preparing and organizing inspection image data (2) training and evaluating a defect detection model using RF-DETR to generate bounding boxes and classify rust severity levels (Slight, Moderate, Severe, Extreme) and (3) integrating the model through an API with a visualization web-based application interface developed using Vue.js, while Python was employed for model training and API services. The result is a prototype web application that accepts user-uploaded images, connects to the AI model API for rust severity classification, and displays bounding boxes, classes, and confidence scores, reducing data consolidation efforts and enhancing transparency in the inspection process.

Introduction

Pipelines are essential for transporting oil, gas, and chemicals, but corrosion and rust can threaten their structural integrity and safety. Traditional inspection methods require extensive manual analysis of images, which is time-consuming and inconsistent. This project presents a web-based system that uses AI and image processing to automatically detect and classify rust severity from pipeline images into four levels: Slight, Moderate, Severe, and Extreme, improving inspection efficiency and accuracy.

Methodology

Data Preparation
Collecting, cleaning, and labeling pipeline images using Roboflow

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Model Training
Training the RF-DETR model to classify rust severity

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Web Application
Developing a user-friendly interface for uploading images and integrating the model via API .

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Evaluation
Assessing model performance using Precision, Recall, and Confusion Matrices to ensure accuracy.

Technologies

Google Colab
Git
FastAPI
Roboflow
Python
Vite.js

Workflow

Data Management → **Model Selection** → **Model Training** → **Model Evaluation** → **Model Testing** → **Model Deployment**

Conclusion

This project successfully implemented a web-based pipeline integrity assessment system utilizing the RF-DETR architecture to automatically detect and classify rust severity into Slight, Moderate, Severe, and Extreme levels. Quantitative evaluation confirmed the model’s high efficiency and accuracy, offering a significant improvement over traditional visual inspections by reducing assessment time. Although limited data for the Severe and Extreme classes presented challenges in classification consistency, the system demonstrates strong potential for industrial application, with future improvements recommended to focus on data augmentation and transfer learning to address dataset imbalances and further refine detection robustness.

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